

Earthquake Recurrence, Clustering, and Persistent Segmentation  
near the Southern End of the 2004 Sunda Megathrust Rupture

Thesis by  
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DEDICATION

to Nick  
to Mom and Dad  
*with gratitude*  
*for your unending love, support, and patience;*  
*you each are my rock*

in memory of  
Adi Rahman Putra  
who gave his life  
in the pursuit of knowledge  
that might someday  
save the lives of others

and in memory of  
all those who lost their lives in 2004  
because we didn't yet know  
of the need to prepare

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## ABSTRACT

The December 2004 moment magnitude ( $M_w$ ) 9.2 earthquake was the largest in the world in four decades. Rupture of the Sunda megathrust in that event produced broad regions of uplift and subsidence. We defined the pivot line separating these regions as a first step in defining the extent of the rupture, relying on the interpretation of satellite imagery and modeled water levels as well as on field measurements of emerged coral microatolls. Uplift in 2004 extended from the middle of Simeulue island, Sumatra, at  $\sim 2.5^\circ\text{N}$ , to Preparis island, Myanmar (Burma), at  $\sim 14.9^\circ\text{N}$ ; thus the 2004 rupture was  $\sim 1600$  km long.

The Sunda megathrust ruptured again in March 2005 in an  $M_w$  8.6 earthquake. We focused our efforts on Simeulue, which straddles the boundary of these two ruptures and behaved as a barrier to both. We extracted records of relative sea-level change from coral microatolls on fringing reefs directly above the southern end of the 2004 rupture and the northern end of the 2005 rupture. These records provide a detailed history of tectonic strain accumulation and release.

Along the coast of northern Simeulue, coral records reveal that predecessors of the 2004 earthquake occurred in the 10th and 14th–15th centuries AD. In the 14th–15th centuries, northern Simeulue experienced a cluster of large megathrust ruptures, associated with total uplift that was considerably more than in 2004. The strain released in 2004 under northern Simeulue took less than 250 years to accumulate if strain accumulation rates since 1948 can be extrapolated back in time. These observations suggest that re-rupture of at least the southernmost 100–200 km of the 2004 patch is possible in the coming decades.

The records from central-southern Simeulue indicate that none of the major uplifts known or inferred on northern Simeulue in the past 1100 years extended to southern Simeulue. In addition, the largest uplifts in the modern or paleogeodetic record in central-southern Simeulue apparently produced little or no uplift in northern Simeulue. These observations suggest that central Simeulue has behaved as a persistent barrier to rupture over at least the past 1100 years.

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